

MANUFACTURING EXCELLENCE THROUGH TOTAL PRODUCTIVE MAINTENANCE IMPLEMENTATION IN AN INDIAN INDUSTRY: A CASE STUDY

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ABSTRACT

A case study on the implementation of TPM initiatives in the engineering industry of India is presented in this paper with an aim to demonstrate the benefits gained by the company after TPM. XYZ Group of industries is operating at three locations in NCR of India and implemented TPM Phase -I and TPM Phase -II successfully in the recent past. The study gives an understanding of the use of TPM and exhibits that TPM is one of the most powerful and efficient business practices to achieve manufacturing excellence. The OEE increased from 46% to 73.1% in TPM Phase-I and 73.1% to 85.5% TPM Phase-II respectively. A number of customer complaints reduced from 150 to zero, production cost decreased by 12% and inventory cost comes down by 35% after the completion of TPM Phase-II. The significant improvements in the TPM effectiveness indicators (PQCDSM) after implementing TPM Phase -I and TPM Phase -II proved that the Advance TPM implementation truly helped the industry in achieving high productivity, excellent quality, lowering manufacturing cost and improved delivery rate.

KEYWORDS: *Total Productive Maintenance (TPM), Overall Equipment Efficiency, Continuous Improvement, Manufacturing Excellence, Availability & TPM Initiatives*

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INTRODUCTION

In the present scenario of globalization, the manufacturing industry worldwide has experienced a drastic change because of the development of new management approaches, product and process technologies, and high customer expectations. Total Productive Maintenance (TPM) refers to a management system for optimizing the productivity in the manufacturing industry through systematic equipment maintenance involving all the employees. TPM is a unique Japanese philosophy which has been developed based on productive maintenance concepts and methodologies. The industry people all over the world are beginning to realize that TPM is a very strong business tool to achieve manufacturing and business excellence. Almost all types of industries have started implementing TPM and are realizing the intended benefits. TPM approach is based upon continuous improvement process and hence can be implemented in phases - Phase-I, Phase-II, Phase-III, etc. to realize manufacturing/business excellence with an ultimate target to become world leaders.

LITERATURE REVIEW

In the present scenario, the companies are focusing to develop their technological base so that they can improve their manufacturing performance. The implementation of TPM is one of the business philosophies to improve the technological base by enhancing equipment efficiency and improving the skill of employees (Adler

and Shenhar, 1990). TPM implementation brings both production and maintenance functions together after initiating good working practices, team working and continuous improvement (Cooke, 2000). The goal of TPM is to continually maintain, improve and maximize the condition and effectiveness of equipment through complete involvement of every employee from top management to shop floor workers (Ireland and Dale, 2006). TPM initiatives in production help in streamlining manufacturing and other business functions, and gaining sustained profits (Ahuja and Khamba, 2007). The challenges before Indian manufacturing industries in implementing TPM initiatives have been identified and strategies for overcoming these challenges are suggested (Ahuja and Khamba, 2008). In TPM, the ultimate aim is to achieve significantly reduced breakdown levels through developing autonomous maintenance teams (Thomas et al., 2008). The implementation of TPM programs in an Indian automobile manufacturing industry through a case study with a purpose to address practical aspects and difficulties in the adoption of TPM is presented (Ravikant V. et al), 2011). The theoretical framework for understanding the use of TPM and how it depends on managerial factors such as JIT, TQM, and TEI as well as environmental and organizational factors such as country and industry characteristics is proposed (McKone K.E., et al), 1999). The benefits achieved after implementing TPM in industries have been well documented by a large number of TPM researchers and they are keen to address the difficulties faced by industry management in implementing TPM, improve its implementation methodology and promote TPM in industry. In this paper, a case study on TPM implementation successfully in three plants of XYZ Group (name changed) situated in NCR of India are highlighted. The real-life improvements in TPM effectiveness indicators (PQCDSM) after implementing TPM in phased manner highlight the impact of TPM implementation in Indian manufacturing industries.

TPM JOURNEY IN XYZ GROUP OF INDUSTRIES – A CASE STUDY

XYZ Group is in the business of manufacturing transmission related auto components such as gears, shafts, flanges for two wheelers, four wheelers and engines, as well as precision forgings. The Group operates three plants situated at three locations A, B & C in the NCR region in India and all of them are certified for Quality Management System (ISO/TS 16949), Environmental Management System (ISO 14000) and Safety and Health Management System (OHSAS 18000). These achievements of the company speak about its value towards customer, employees, and society as a whole. To achieve a competitive advantage and remain on the leading edge, the management of this group implemented the TPM initiatives in all the three plants to overcome the following mentioned business challenges:

- The availability of the plants was low due to various production losses.
- Line operating efficiency was low due to poor ergonomics and unbalanced plant layout.
- Poor product quality due to in-process defects.
- Increased input costs due to hike in prices of materials, power, and fuel.
- Enhanced labor cost and high capital cost
- There was high set up time and lead time, due to this there was a mismatch with market requirements of low volumes and high varieties
- There was pressure from various regulatory bodies to maintain safety, health & environmental norms.
- Workforce mismatch with skill requirements.

XYZ Group under the supervision of a TPM consultant from JIPM set the goals of implementing TPM after analyzing the existing conditions of all the plants which were supposed to be result oriented, specific, measurable, attainable and realistic. TPM policies, objectives, targets, organizational structure as well as all necessary procedures were formulated to initiate the TPM implementation.

TPM starts with 5'S and is in practice at XYZ Group for the last ten years. It is a systematic process of housekeeping to achieve a serene environment in the workplace. The TPM Pillars have been implemented in a planned and systematic manner to improve the shop-floor system to prevent losses before they occur throughout the entire production system life cycle with a view to achieving zero accidents, zero defects, and zero breakdowns. The other important aspects such as improved office automation, safety, health, and environment are also addressed by TPM activities.

TPM Implementation Methodology

The TPM implementation methodology adopted by the company consists of the following four stages and twelve steps as per JIPM guidelines:

- Introduction-preparatory stage: Steps 1 to 5
- Start of introduction: Step 6
- Introduction-execution stage: Steps 7 to 11
- Established stage: Step 12

The step-by-step TPM implementation process is presented below:

Stage I - Introduction-Preparatory Stage: Steps 1 to 5

Step-1: Top Person's Announcement to Introduce TPM

The top-level management of XYZ Group decided to implement Total Productive Maintenance (TPM) philosophy in it's all the three plants simultaneously and announced its implementation companywide in May 2005.

Step-2: TPM Education and Training

To initiate TPM activities, training programs on the following issues were held for imparting technical knowledge and understanding of a broad range of skills on TPM:

- Total Productive Maintenance (TPM), its advantages and challenges, implementation plan and how to measure TPM progress.
- Overall Equipment Efficiency (OEE) as being the true measure of TPM, its importance and calculation method.
- 5S and its implementation methodology to improve productivity, quality, and safety.
- Categorization of losses into six big losses, their overcoming to improve the OEE.
- Preventive maintenance with a focus on "Cleaning is maintaining".

Step-3: TPM Organizational Team Formulation

TPM has 8 pillars of activities and individual TPM Pillar committees were formulated with one pillar chairman heading the committee under TPM plant promotion management committee chairman. Members from various departments were nominated as pillar representatives. Monthly apex meetings were conducted and pillar chairman used to present the monthly progress to the unit head. Pillar members had to present the progress of their respective pillars to the chairman in fortnightly review meetings. Pillar chairman used to provide all necessary support and guidance to his pillar members.

Step-4: Setting of TPM Policy, Objectives and Targets

The Company formulated the TPM policy, objectives and targets as mentioned below:

TPM Policy

- To maximize overall equipment effectiveness by minimizing breakdowns, defects, and losses.
- To create well-engineered equipment and processes and achieve operational reliability, maintainability, flexibility, operability, and safety.
- To effectively utilize resources such as raw materials, tools, consumables, and energy.
- To develop employees competency to utilize their full potential.

TPM Objectives

- To maximize capacity utilization.
- Supply of high-quality products to customers.
- To minimize the cost of operations.
- On time delivery and inventory reduction.
- Lead time reduction in manufacturing and new product development.
- Safe, hygienic and environment-friendly workplace.
- High skill and morale of employees

TPM Targets

- Overall equipment effectiveness shall be more than 85%.
- Production volume shall be 1.5 times the benchmark value.
- In –process defects shall be one-tenth to benchmark value.
- Reduce the cost of operation by 20%
- 100% and on-time delivery to customers.
- Product inventory reduction by 50%.
- New product development time reduction by 50%.

- Zero accidents, zero customer complaints, and zero pollution.
- Material/Document retrieval (traceability) must be less than 30 seconds.
- Ten folds increase in Kaizens.

Step-5: Preparation of a Master Plan for Implementing TPM

Detailed master plans for all the eight pillars to be implemented in respective plants were prepared. These master plans were followed strictly by all the pillar heads for the successful TPM implementation.

Stage II - Start of Introduction: Step 6

Step-6: TPM Kick-off Ceremony

Initially TPM initiatives were implemented on manager model machines before companywide deployment of all the eight pillar activities for the motivation of all employees. Ten machines were identified as manager model machines from three plants and only three steps (Step 1, 2, 3) of Jishu Hozen were implemented on these machines. After implementing the first three steps of Kobetsu Kaizen Pillar, all other pillars activities were also implemented in parallel on them. The progress of improvement in manager model machines was audited by the consultant from time to time until the desired level of improvement had taken place. Then TPM Kick-off ceremony was held on 06.06.2006 and companywide deployment of all the eight pillars of TPM with their activities were started from July 2006.

Stage III- Introduction-Execution Stage: Steps 7 to 11

Step-7: Establishment of a system for improving the efficiency of the production department. The JH, KK, PM and E&T pillars activities were performed as mentioned in table-1.

Step-8 Deployment of Initial Control Pillar Initiatives

Initial Control Preparatory Activities

- Formation of initial control sub-committees.
- Awareness training to sub-committee members and users.
- Deployment of Maintenance Prevention (MP) System.

Development of new equipment initial control system

- Development of new product initial control system
- Review of new equipment initial control system.
- Horizontal Deployment.

Deployment of new product initial control system

- Deployment of new product initial control system
- v) Improvement activities to reduce new product development time.

Table 1

	Deployment of the First Four TPM Pillarones Implementation Initiatives
Step-7.1	<p>Jishu Hozen (JH) Pillar Activities</p> <p><i>A. Manager model Machine Activities:</i></p> <p>i) Team formation, selection of model machines and initiate three JH steps on them.</p> <p>ii) Step 1: Initial cleaning</p> <p>iii) Step 2: Countermeasures for sources of contamination and difficult to access areas</p> <p>iv) Step 3: Tentative Autonomous maintenance standards</p> <p><i>B. Preparatory Activities for full-scale deployment at the plant level:</i></p> <p>i) Establishment of JH organization team, sub-committees and circles formulation.</p> <p>ii) Awareness training to all subcommittee members, and circle members.</p> <p>iii) Preparation of JH Circles activity Plan.</p> <p>iv) Procurement of maintenance tools and aids for circle activities</p> <p><i>C. Full-scale Jishu Hozen Deployment:</i></p> <p>i) Step 1: Initial Cleaning</p> <p>ii) Step 2: Countermeasures for sources of contamination and difficult to access areas</p> <p>iii) Step 3: Tentative Autonomous Maintenance Standards</p> <p>iv) Step 4: General Inspection</p> <p>v) Step 5: Autonomous Inspection</p>
Step-7.2	<p>Kobetsu Kaizen (KK) Pillar activities:</p> <p>i) Companywide training on Kobetsu Kaizen activities</p> <p>ii) Identification of all organizational losses and loss definition</p> <p>iii) Derivation of the formula for each loss amount</p> <p>iv) Create a mechanism for data collection for each loss</p> <p>vii) Create the database for each loss, productivity, and cost</p> <p>viii) Structure for Pareto analysis of loss time and loss amount</p> <p>ix) Set pillar targets and theme selection</p> <p>x) Formulate the process of Kaizen registration and follow up</p> <p>xi) Kobetsu Kaizen model theme deployment</p> <p>xii) Monitoring the loss amount savings and loss time reduction</p>
Step-7.3	<p>Planned Maintenance (PM) Pillar Activities</p> <p>Six Step Methodology was used to implement Planned Maintenance pillar activities:</p> <p>Step 1: Evaluate equipment and grasp the present status</p> <p>Step 2: Restore deterioration and improve weaknesses</p> <p>Step3: Build an information management system</p> <p>Step 4: Build a periodic maintenance system</p> <p>Step 5: Building a predictive maintenance system</p> <p>Step 6: Evaluate plant maintenance system</p>
Step-7.4	<p>Education and Training (E&T) Pillar Activities</p> <p>i) Deployment of education and training system</p> <p>ii) Skill evaluation and follow up</p> <p>iii) Training on JH step 4: General inspection to operators, theory and practical training on skill development on bolts and nuts, transmission system, hydraulic system, lubrication system, pneumatic system, basic electrical system, etc.</p>

Step-9: Deployment of Quality Maintenance Pillar Initiatives

Initiated the following activities:

- Past customer complaints data analysis and theme up activity
- Defects Outflow Prevention activity-Poke yoke, etc.
- In-process defects data analysis and theme-up activity.
- First Piece and Last Piece control system.
- Quality control audits.

- Maintenance and Control audits

Step-10: Deployment of Office TPM Pillar Initiatives

- Deployment of Jishu Hozen Step 1,2 and 3 in offices.
- Deployment of Kobetsu Kaizen activities to reduce office cost.
- Deployment of Kobetsu Kaizen activities to reduce logistics cost.
- Maintenance of Information Management, Maintenance cost control.

Step-11: Deployment of Safety, Health & Environment Initiatives

- Measures for the elimination of accidents and improving Safety.
- Measures for the elimination of health-related abnormalities.
- Measures for the elimination of environment-related abnormalities.

Stage-IV - Established Stage: Step 12

Step-12: Receipt of Awards

XYZ Group implemented TPM Phase-I successfully by early June 2009 and achieved all the desired TPM targets. The company became eligible for challenging the TPM excellence award as per JIPM guidelines and received “Category-A” TPM excellence award on January 28, 2010, from JIPM. The company again decided to continue the TPM journey in its all plants and the Kick-Off ceremony for TPM Part-II was held on 3rd March 2010. The Group got awarded “Category-A” Award for Excellence in Consistent TPM Commitment in recent past from JIPM.

RESULTS AND DISCUSSIONS

XYZ group of industries is one of the select groups of companies to have achieved this feat of successfully completing the TPM Part-II journey. The pillar wise achievements obtained after implementation of TPM in one of the plants of the XYZ group are given below:

Jishu Hozen Pillar Targets Achieved:

JH Pillar helped in increasing the competence level of operators in maintaining their own equipment and processes. The following are the pillar achievements:

Table 2: Jishu Hozen Targets Achieved

Jishu Hozen Activity Targets		Before TPM	After TPM
1.	Reduction in Cleaning, Inspection and Lubrication time (Time saved in hours)	20	280
2	Reduction in a number of breakdowns due to inadequate basic conditions.	830	40
3	Increase in %age of breakdowns attended by Operators	50	95
4	Reduction in a number of Minor stoppage losses.	800	120
5	Increase in a number of Kaizens implementation.	70	2000

Kobetsu Kaizen Pillar Targets Achieved

The aim of the pillar remained successful to achieve total elimination of equipment related losses and wastes for increasing capacity utilization and measures to create additional capacity for future business needs without employing additional capital cost. Focus on direct cost reduction by attacking losses such as energy losses, material yield loss and tools cost contributed to achieving following pillar targets.

Kobetsu Kaizen Targets Achieved

Table 3

Kobetsu Kaizen Activity Targets				Before TPM	After TPM
1.0	Profit	1.1	Profit amount (Millions of Rupees)	17.66	34.8
		1.2	Profit rate (% of Sales)	6.22	8.5
2.0	Sales Turnover (Millions of Rupees)			283.8	400
3.0	Production Cost (% of Sales)			26.7	14
4.0	Productivity	4.1	Plant OEE (% age)	38.6	80
		4.2	Plant Labour Productivity (Millions of Rupees)	3.68	4.00
5.0	Delivery	5.1	Delivery rate (% age)	68	100
		5.2	Inventory Turn Ratio (Millions of Rupees)	17	25
6.0	Cost Saving	6.1	Millions of Rupees	-	35
7.0	Improvement in Themes - Registered / Completed	7.1	Type " A " themes (Numbers)	1	50
		7.2	Type " B " themes (Numbers)	3	150
		7.3	Type " C " themes (Numbers)	2	150

Planned Maintenance Pillar Targets Achieved

Reduced breakdowns and sustaining the same by the rigorous deployment of condition-based monitoring (CBM) helped to reduce operational cost. The following are the pillar achievements:

Table 4: Planned Maintenance Targets Achieved

Planned Maintenance Activity Targets				Before TPM	After TPM
1.0	Reduction in Breakdown Frequency (Numbers)	1.1	Total breakdowns	1300	45
		1.2	Major breakdowns	400	9
		1.3	Medium Breakdowns	600	27
		1.4	Minor Breakdowns	300	18
2.0	Reduction in Breakdown time	Total Time Reduction (Hours)		220	1500
3.0	Reduction in Maintenance Cost	Cost In Rupees (Millions of rupees)		200	20
4.0	Increase in MTBF	Time GAP (Hours)		2	120
5.0	Reduction in MTTR	Time GAP (Hours)		20	1

Quality Maintenance Pillar Targets Achieved

The rigorous deployment of Quality Maintenance pillar helped in achieving the following targets:

Table 5: Quality Maintenance Activity Targets

Quality Maintenance Activity Targets			Before TPM	After TPM
1	Customer Complaints		1200	86
2	Defects Rate (PPM in %)		55000	300
3	Number of Defectives produced (Numbers)		580	20

Table 5: Contd.,			
4	Improvement themes Completed (Numbers)	80	1200
5	Poka yoke implementation (Numbers)	20	460

Initial Control Pillar Targets Achieved

The efficient deployment of new equipment initial control system helped to get equipment of high reliability, maintainability, flexibility, operability, safety whereas deployment of new product initial control system contributed to reducing new product development time in new business. The following are the pillar achievements:

Table 6: Initial Control Targets Achieved

Initial Control Activity Targets				Before TPM	After TPM
1	Establishment of Maintenance Prevention System	1.1	Number of MP information gathered (Numbers)	0	40
		1.2	Number of MP information utilized. (Numbers)	0	100%
2	Establishment of New equipment initial control System	2.1	Number of equipment under initial control (Numbers)	0	100%
		2.2	Duration of Vertical Start-up (Days)	7 days	2 Days.
3	Establishment of New Product initial control System	3.1	New Product development Lead time (Days)	140.00	75.00
		3.2	Cost of development of New Products (Rs. in Lakhs)	3.00	2.00
		3.3	Number of Prototypes used (Numbers)	Nil	Nil
		3.4	Number of New Products developed (Numbers)	Nil	12.00

Education and Training Pillar Targets Achieved

Increased continuous improvement skills through education and training helped in achieving the following targets:

Table 7: Education and Training Targets Achieved

Education and Training Activity Targets		Before TPM	After TPM
1.0	Increase in Skill level index (Number)	25	92
2.0	Increase in training time (Number of hours/ year)	10	85

Safety, Health, and Environment Pillar Targets Achieved

This pillar remained successful in creating a safe and healthy workplace everywhere in all the plants where accidents do not occur and improved hazardous areas. The key achievements of this pillar are:

Table 8: Safety, Health, and Environment Targets Achieved

Safety, Health, and Environment Activity Targets			Before TPM	After TPM
Safety Number of Accidents	1.1	Reportable accidents	20	1
	1.2	Non Reportable accidents	80	4
	1.3	First aid cases	230	15
Shop Floor Environment	2.1	Number of zones where the Noise level is high (Numbers)	14	1
	2.2	Number of zones where lighting level is low (Numbers)	20	2
	2.3	Number of Zones where the temperature is high (Numbers)	5	0
	2.4	Number of zones where air pollution is high (Numbers)	6	0

Table 8: Contd.,				
Plant Surrounding Environment	3.1	Quantum of contaminant discharge to plant vicinity (Kilograms)	50	2
Global Environment	4.1	Number of areas of Land Contamination (Numbers)	4	0
	4.2	Number of zones against global Pollution norms / emission standards (Numbers)	2	0

Office TPM Pillar Targets Achieved

After giving focus on the reduction of office cost, logistics cost and inventory cost, the following pillar targets are achieved:

Table 9: Office TPM Targets Achieved

Office TPM Activity Targets		Before TPM	After TPM
1.0	Reduction in Office Cost (% of Sales)	15	5
2.0	Reduction in Logistics Cost (% of Sales)	20	8
3.0	Office Focused improvement themes - Registered / Completed (Numbers)	190	20

Overall Benefits of TPM Implementation

TPM implementation in XYZ Group remained very successful. The overall important tangible and intangible benefits achieved by the industry after the implementation of both TPM Phase-I & Phase-II are highlighted as:

Tangible Benefits Achieved

The improvements occurred in the TPM effectiveness indicators (PQCDSM) after implementing TPM Phases -I and II are presented in table-4.9.

Table 10: Tangible Benefits after TPM Phase -I and TPM Phase –II

Category	Parameter	Units	Benchmark	TPM Phase-I Target Achieved	TPM Phase-II Target Achieved
P	OEE	% Improved	46	73.1	85.5
	Breakdowns	% Reduced	-	20	20
Q	Customer Complaints	Nos./Month	150	15	zero
	Defect Rate	% Reduced	-	20	20
C	Production Cost	% Reduced	-	9	12
D	Delivery Rate	% Improved	83	99	100
	Inventory Cost	% Reduced	-	20	35
S	First aid cases	% Reduced	-	33	20
M	No. of improvement themes carried out	Nos.	-	470	873
	No. of Kaizens done from April 2008	No. of times	1	1.9	2.5

Intangible Result Achieved

The following are the Intangible benefits achieved by the company:

- Increase in the ownership of equipment and workplace by the operator.
- Increase in confidence and ability of operators and staff to perform complex jobs/problems.

- Development of clean, dry, bright, visual and lively workplaces.
- Appreciation from customers and other visitors during plant visits.
- Increase in team spirit and group behavior in operators and staff.
- Multiskill abilities attained by operators

CONCLUSIONS

The significant improvement in productivity, quality, and morale of employees, and a good decrease in labor/maintenance/inventory costs are the prime benefits achieved by the company. The Overall Equipment Efficiency (OEE) increased from 46% to 73.1% and then to 85.5% in TPM Phase-I and TPM Phase-II respectively. A number of customer complaints reduced from 150 to zero, production cost reduced by 12% and inventory cost lowered by 35% with the completion of TPM Phase-II. With all these improvements, the delivery rate improved from 83% to 100% which is a remarkable achievement. Thus it is proved that TPM implementation in XYZ Group remained very successful in improving the organization's competitiveness, manufacturing performance and productivity by making the processes more reliable and less wasteful.

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